Low Skew, Dual, 1-to-3, Differential-to-2.5V, 3.3V LVPECL/ECL Fanout Buffer

ICS853S013I

DATASHEET

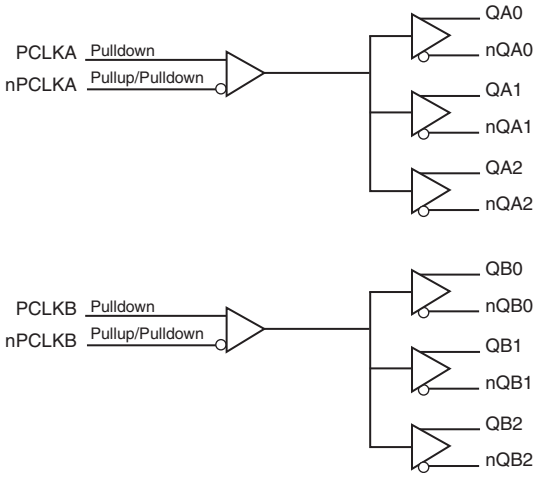
General Description

The ICS853S013I is a low skew, high performance dual 1-to-3 Differential-to-2.5V, 3.3V LVPECL/ ECL Fanout Buffer. The ICS853S013I operates with a positive or negative power supply at 2.5V or 3.3V. Guaranteed output and part-to-part skew characteristics make the ICS853S013I ideal for those clock distribution applications demanding well defined performance and repeatability.

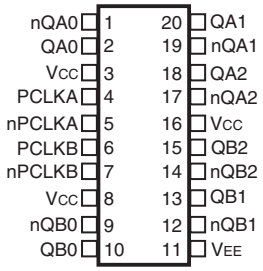
Features

- Two differential LVPECL/ECL bank outputs
- Two differential LVPECL clock input pairs
- PCLKx, nPCLKx pairs can accept the following differential input levels: LVPECL, LVDS, CML, SSTL
- Output frequency: 2GHz (maximum)
- Translates any single-ended input signal to LVPECL levels with resistor bias on nPCLKx input
- Bank skew: 60ps (maximum)
- Part-to-part skew: 190ps (maximum)
- Propagation delay: 460ps (maximum)
- Additive phase jitter, RMS: 0.05ps (typical)
- LVPECL mode operating voltage supply range: V_{CC} = 2.375V to 3.8V, V_{EE} = 0V
- ECL mode operating voltage supply range: V_{CC} = 0V, V_{EE} = -3.8V to -2.375V
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

Block Diagram



Pin Assignment



ICS853S013I

20-Lead SOIC
7.5mm x 12.8mm x 2.3mm package body
M Package
Top View

Table 1. Pin Descriptions

Number	Name	Type		Description
1, 2	nQA0, QA0	Output		Differential output pair. LVPECL interface levels.
3, 8, 16	V_{CC}	Power		Power supply pins.
4	PCLKA	Input	Pulldown	Non-inverting differential LVPECL clock input.
5	nPCLKA	Input	Pullup/ Pulldown	Inverting differential LVPECL clock input. $V_{CC}/2$ default when left floating.
6	PCLKB	Input	Pulldown	Non-inverting differential LVPECL clock input.
7	nPCLKB	Input	Pullup/ Pulldown	Inverting differential LVPECL clock input. $V_{CC}/2$ default when left floating.
9, 10	nQB0, QB0	Output		Differential output pair. LVPECL interface levels.
11	V_{EE}	Power		Negative supply pin.
12, 13	nQB1, QB1	Output		Differential output pair. LVPECL interface levels.
14, 15	nQB2, QB2	Output		Differential output pair. LVPECL interface levels.
17, 18	nQA2, QA2	Output		Differential output pair. LVPECL interface levels.
19, 20	nQA1, QA1	Output		Differential output pair. LVPECL interface levels.

NOTE: *Pullup and Pulldown* refer to internal input resistors. See Table 2, *Pin Characteristics,* for typical values.

Table 2. Pin Characteristics

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$R_{PULLDOWN}$	Input Pulldown Resistor			75		kΩ
$R_{VCC/2}$	Pullup/Pulldown Resistors			50		kΩ

Function Table

Table 3. Clock Input Function Table

Inputs		Outputs		Input to Output Mode	Polarity
PCLKA or PCLKB	nPCLKA or nPCLKB	QA[0:2], QB[0:2]	nQA[0:2], nQB[0:2]		
0	1	LOW	HIGH	Differential to Differential	Non-Inverting
1	0	HIGH	LOW	Differential to Differential	Non-Inverting
0	Biased; NOTE 1	LOW	HIGH	Single-Ended to Differential	Non-Inverting
1	Biased; NOTE 1	HIGH	LOW	Single-Ended to Differential	Non-Inverting
Biased; NOTE 1	0	HIGH	LOW	Single-Ended to Differential	Inverting
Biased; NOTE 1	1	LOW	HIGH	Single-Ended to Differential	Inverting

NOTE 1: Please refer to the Application Information, *Wiring the Differential Input to Accept Single Ended Levels.*

Absolute Maximum Ratings

NOTE: Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics or AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

Item	Rating
Supply Voltage, V_{CC}	4.6V (LVPECL mode, V_{EE} = 0V)
Negative Supply Voltage, V_{EE}	-4.6V (ECL mode, V_{CC} = 0V)
Inputs, V_I (LVPECL mode)	-0.5V to V_{CC} + 0.5V
Inputs, V_I (ECL mode)	0.5V to V_{EE} – 0.5V
Outputs, I_O Continuous Current Surge Current	 50mA 100mA
Operating Temperature Range, T_A	-40°C to +85°C
Package Thermal Impedance, θ_{JA}	71.1°C/W (0 mps)
Storage Temperature, T_{STG}	-65°C to 150°C

DC Electrical Characteristics

Table 4A. Power Supply DC Characteristics, V_{CC} = 2.375V to 3.8V; V_{EE} = 0V, T_A = -40°C to 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{CC}	Positive Supply Voltage		2.375	3.3	3.8	V
I_{EE}	Power Supply Current				50	mA

Table 4B. LVPECL DC Characteristics, V_{CC} = 3.3V, V_{EE} = 0V; T_A = -40°C to 85°C

Symbol	Parameter		-40°C			25°C			85°C			Units
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{OH}	Output High Voltage; NOTE 1		2.175	2.275	2.50	2.225	2.295	2.495	2.295	2.33	2.485	V
V_{OL}	Output Low Voltage; NOTE 1		1.405	1.545	1.68	1.425	1.52	1.65	1.44	1.535	1.62	V
V_{IH}	Input High Voltage (Single-ended)		2.075		2.36	2.075		2.36	2.075		2.36	V
V_{IL}	Input Low Voltage (Single-ended)		1.43		1.765	1.43		1.765	1.43		1.765	V
V_{PP}	Peak-to-Peak Input Voltage		150	800	1200	150	800	1200	150	800	1200	mV
V_{CMR}	Input High Voltage Common Mode Range; NOTE 2, 3		1.2		3.3	1.2		3.3	1.2		3.3	V
I_{IH}	Input High Current	PCLKA, PCLKB nPCLKA, nPCLKB			150			150			150	µA
I_{IL}	Input Low Current	PCLKA, PCLKB	-10			-10			-10			µA
		nPCLKA, nPCLKB	-150			-150			-150			µA

NOTE: Input and output parameters vary 1:1 with V_{CC}. V_{CC} can vary -0.925V to +0.5V.
NOTE 1: Outputs terminated with 50Ω to V_{CC} – 2V.
NOTE 2: Common mode voltage is defined as V_{IH}.
NOTE 3: For single-ended applications, the maximum input voltage for PCLKx, nPCLKx is V_{CC} + 0.3V.

Table 4C. LVPECL DC Characteristics, V_{CC} = 2.5V, V_{EE} = 0V; T_A = -40°C to 85°C

Symbol	Parameter		-40°C			25°C			85°C			Units
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{OH}	Output High Voltage; NOTE 1		1.375	1.475	1.70	1.425	1.495	1.69	1.495	1.53	1.685	V
V_{OL}	Output Low Voltage; NOTE 1		0.605	0.745	0.92	0.625	0.72	0.90	0.64	0.735	0.89	V
V_{IH}	Input High Voltage (Single-ended)		1.275		1.56	1.275		1.56	1.275		-0.8	V
V_{IL}	Input Low Voltage (Single-ended)		0.63		0.965	0.63		0.965	0.63		0.965	V
V_{PP}	Peak-to-Peak Input Voltage		150	800	1200	150	800	1200	150	800	1200	mV
V_{CMR}	Input High Voltage Common Mode Range; NOTE 2, 3		1.2		2.5	1.2		2.5	1.2		2.5	V
I_{IH}	Input High Current	PCLKA, PCLKB nPCLKA, nPCLKB			150			150			150	µA
I_{IL}	Input Low Current	PCLKA, PCLKB	-10			-10			-10			µA
		nPCLKA, nPCLKB	-150			-150			-150			µA

NOTE: Input and output parameters vary 1:1 with V_{CC}. V_{CC} can vary -0.925V to +0.5V.
NOTE 1: Outputs terminated with 50Ω to V_{CC} – 2V.
NOTE 2: Common mode voltage is defined as V_{IH}.
NOTE 3: For single-ended applications, the maximum input voltage for PCLKx, nPCLKx is V_{CC} + 0.3V.

Table 4D. ECL DC Characteristics, V_{CC} = 0V, V_{EE} = -3.8V to -2.375V, T_A = -40°C to 85°C

Symbol	Parameter		-40°C			25°C			85°C			Units
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
V_{OH}	Output High Voltage; NOTE 1		-1.125	-1.025	-0.80	-1.075	-1.005	-0.805	-1.005	-0.97	-0.815	V
V_{OL}	Output Low Voltage; NOTE 1		-1.895	-1.755	-1.62	-1.875	-1.78	-1.65	-1.86	-1.765	-1.68	V
V_{IH}	Input High Voltage (Single-ended)		-1.225		-0.94	-1.225		-0.94	-1.225		-0.94	V
V_{IL}	Input Low Voltage (Single-ended)		-1.87		-1.535	-1.87		-1.535	-1.87		-1.535	V
V_{PP}	Peak-to-Peak Input Voltage		150	800	1200	150	800	1200	150	800	1200	mV
V_{CMR}	Input High Voltage Common Mode Range; NOTE 2, 3		V_{EE}+1.2		0	V_{EE}+1.2		0	V_{EE}+1.2		0	V
I_{IH}	Input High Current	PCLKA, PCLKB nPCLKA, nPCLKB			150			150			150	µA
I_{IL}	Input Low Current	PCLKA, PCLKB	-10			-10			-10			µA
		nPCLKA, nPCLKB	-150			-150			-150			µA

NOTE 1: Outputs terminated with 50Ω to V_{CC} – 2V.
NOTE 2: Common mode voltage is defined as V_{IH}.
NOTE 3: For single-ended applications, the maximum input voltage for PCLKx, nPCLKx is V_{CC} + 0.3V

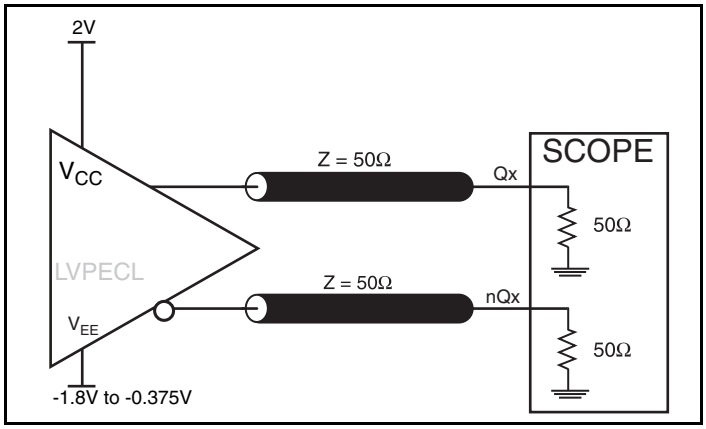
AC Electrical Characteristics

Table 5. AC Characteristics, V_{CC} = -3.8V to -2.375V or , V_{CC} = 2.375V to 3.8V; V_{EE} = 0V; T_A = -40°C to 85°C

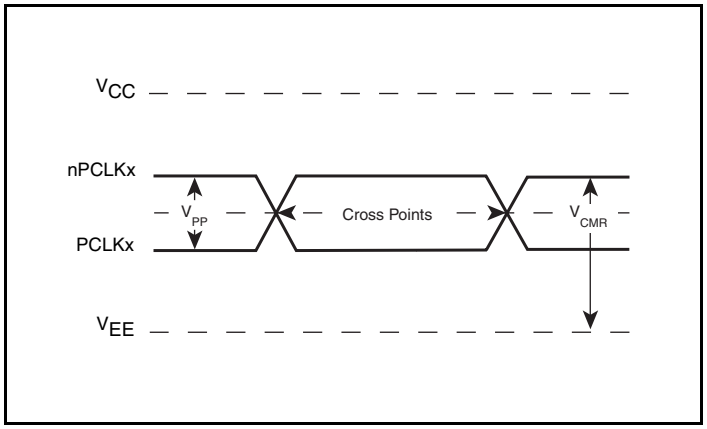
Symbol	Parameter		-40°C			25°C			85°C			Units
			Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
f_{MAX}	Output Frequency				2			2			2	GHz
tP_{LH}	Propagation Delay; Low-to-High; NOTE 1		230		420	250		440	270		460	ps
tP_{HL}	Propagation Delay; High-to-Low; NOTE 1		230		420	250		440	270		460	ps
*t*sk(b)	Bank Skew; NOTE 2, 4				60			60			60	ps
*t*sk(odc)	Output Duty Cycle Skew				40			40			40	ps
*t*sk(pp)	Part-to-Part Skew; NOTE 3, 4				190			190			190	ps
*t*jit	Buffer Additive Phase Jitter, RMS; refer to Additive Phase Jjitter Section			0.03			0.05			0.08		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	120		250	120		250	120		250	ps

NOTE: All parameters are measured at f ≤ 1GHz, unless otherwise noted.
NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.
NOTE 1: Measured from the differential input crossing point to the differential output crossing point.
NOTE 2: Defined as skew within a bank of outputs at the same voltages and with equal load conditions.
NOTE 3: Defined as skew between outputs on different devices operating at the same supply voltages and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at the differential cross points.
NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.

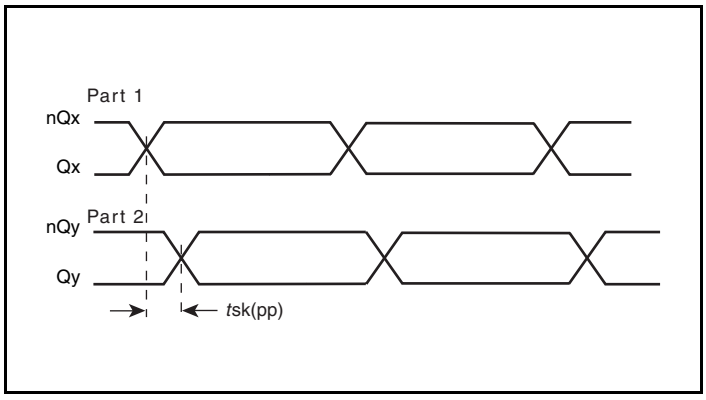
Parameter Measurement Information



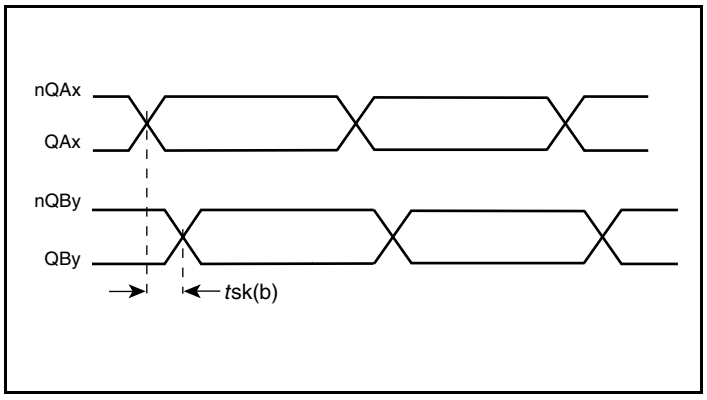
LVPECL Output Load AC Test Circuit



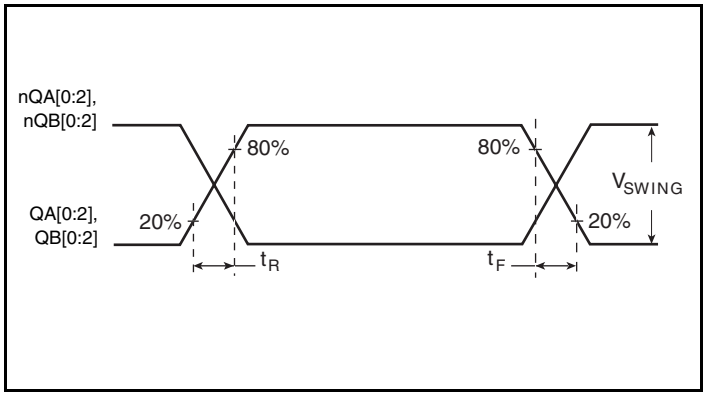
Differential Input Level



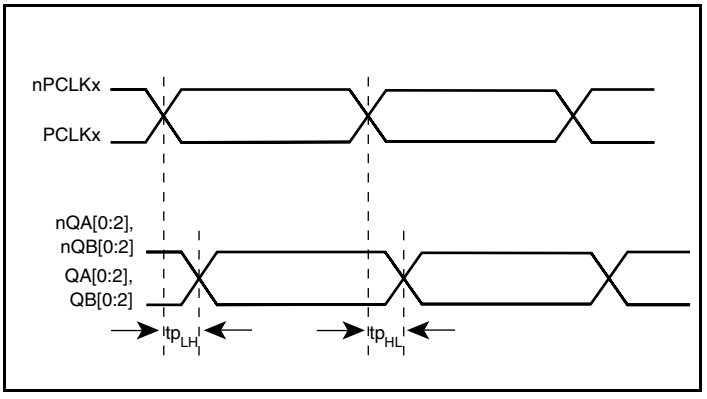
Part-to-Part Skew



Bank Skew

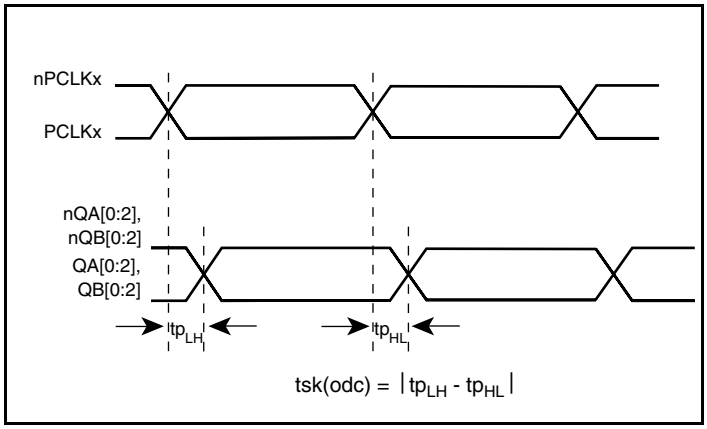


Output Rise/Fall Time



Propagation Delay

Parameter Measurement Information, continued



Output Duty Cycle Skew

Application Information

Wiring the Differential Input to Accept Single-Ended Levels

Figure 1 shows how a differential input can be wired to accept single ended levels. The reference voltage $V_{REF} = V_{CC}/2$ is generated by the bias resistors R1 and R2. The bypass capacitor (C1) is used to help filter noise on the DC bias. This bias circuit should be located as close to the input pin as possible. The ratio of R1 and R2 might need to be adjusted to position the V_{REF} in the center of the input voltage swing. For example, if the input clock swing is 2.5V and V_{CC} = 3.3V, R1 and R2 value should be adjusted to set V_{REF} at 1.25V. The values below are for when both the single ended swing and V_{CC} are at the same voltage. This configuration requires that the sum of the output impedance of the driver (Ro) and the series resistance (Rs) equals the transmission line impedance. In addition, matched termination at the input will attenuate the signal in half. This can be done in one of two ways. First, R3 and R4 in parallel should equal the transmission line impedance. For most 50Ω applications, R3 and R4 can be 100Ω. The values of the resistors can be increased to reduce the loading for slower and weaker LVCMOS driver. When using single-ended signaling, the noise rejection benefits of differential signaling are reduced. Even though the differential input can handle full rail LVCMOS signaling, it is recommended that the amplitude be reduced. The datasheet specifies a lower differential amplitude, however this only applies to differential signals. For single-ended applications, the swing can be larger, however V_{IL} cannot be less than -0.3V and V_{IH} cannot be more than V_{CC} + 0.3V. Though some of the recommended components might not be used, the pads should be placed in the layout. They can be utilized for debugging purposes. The datasheet specifications are characterized and guaranteed by using a differential signal.

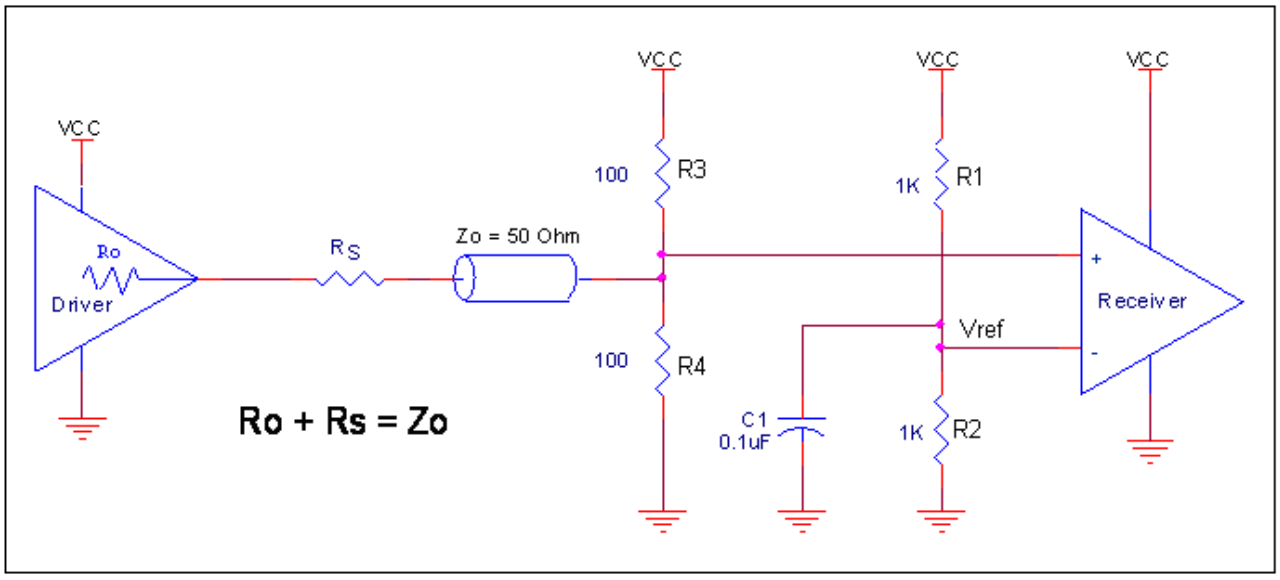


Figure 1. Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels

LVPECL Clock Input Interface

The PCLK/nPCLK accepts LVPECL, LVDS, CML, SSTL and other differential signals. Both V_{SWING} and V_{OH} must meet the V_{PP} and V_{CMR} input requirements. *Figures 2A to 2F* show interface examples for the PCLK/nPCLK input driven by the most common driver types.

The input interfaces suggested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.

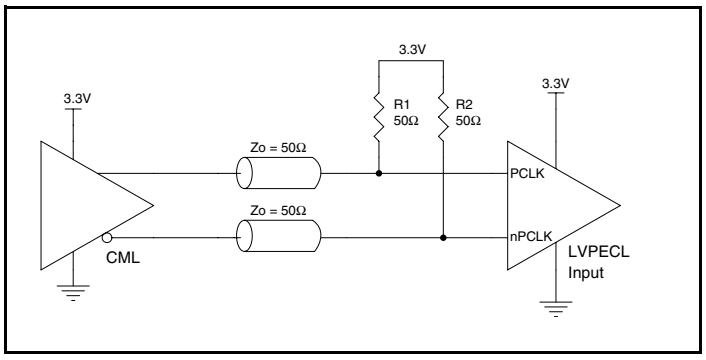


Figure 2A. PCLK/nPCLK Input Driven by an Open Collector CML Driver

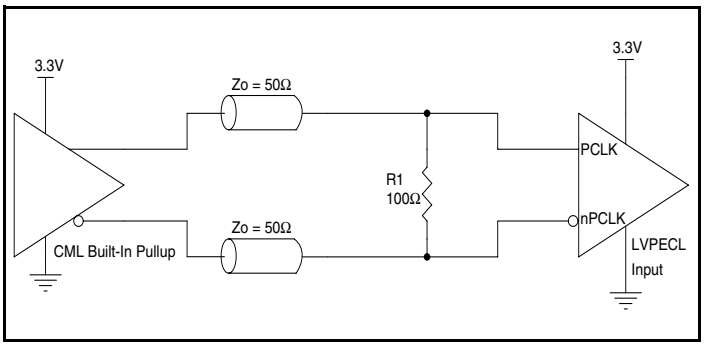


Figure 2B. PCLK/nPCLK Input Driven by a Built-In Pullup CML Driver

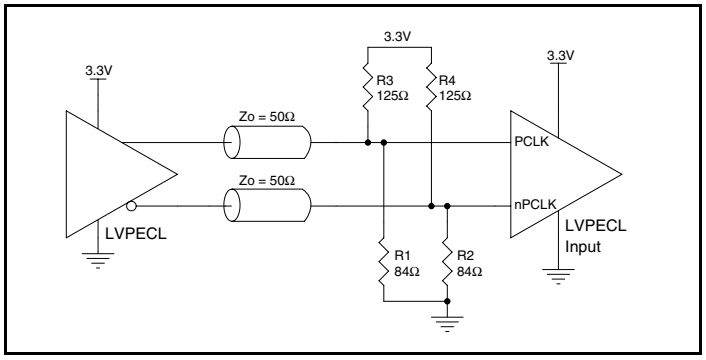


Figure 2C. PCLK/nPCLK Input Driven by a 3.3V LVPECL Driver

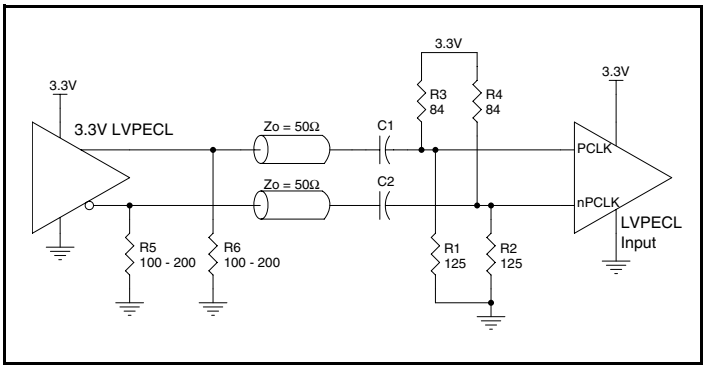


Figure 2D. PCLK/nPCLKInput Driven by a 3.3V LVPECL Driver with AC Couple

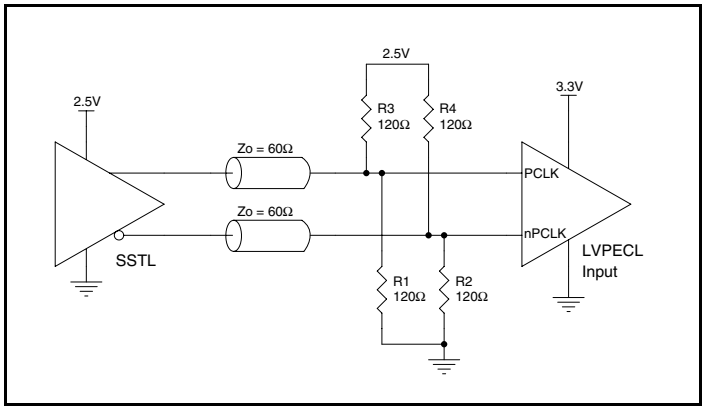


Figure 2E. PCLK/nPCLK Input Driven by an SSTL Driver

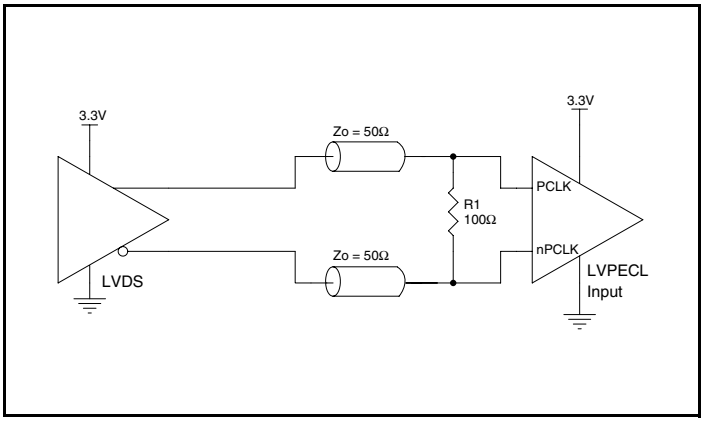


Figure 2F. PCLK/nPCLK Input Driven by a 3.3V LVDS Driver

Recommendations for Unused Output Pins

Inputs:

PCLKx/nPCLKx Inputs

For applications not requiring the use of a differential input, both the PCLKx and nPCLKx pins can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from PCLKx to ground. For applications

Outputs:

LVPECL Outputs

All unused LVPECL outputs can be left floating. We recommend that there is no trace attached. Both sides of the differential output pair should either be left floating or terminated.

Termination for 3.3V LVPECL Outputs

The clock layout topology shown below is a typical termination for LVPECL outputs. The two different layouts mentioned are recommended only as guidelines.

The differential outputs are low impedance follower outputs that generate ECL/LVPECL compatible outputs. Therefore, terminating resistors (DC current path to ground) or current sources must be used for functionality. These outputs are designed to drive 50Ω transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 3A and 3B* show two different layouts which are recommended only as guidelines. Other suitable clock layouts may exist and it would be recommended that the board designers simulate to guarantee compatibility across all printed circuit and clock component process variations.

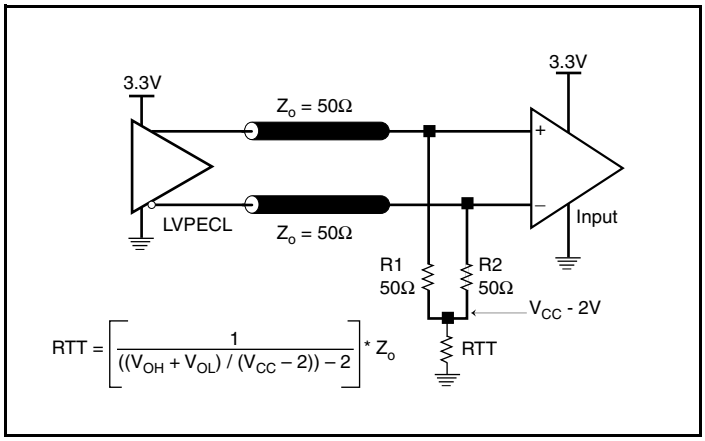


Figure 3A. 3.3V LVPECL Output Termination

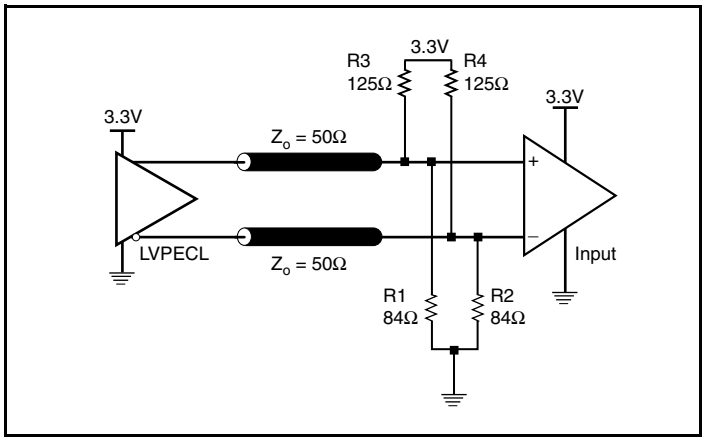


Figure 3B. 3.3V LVPECL Output Termination

Termination for 2.5V LVPECL Outputs

Figure 4A and *Figure 4B* show examples of termination for 2.5V LVPECL driver. These terminations are equivalent to terminating 50Ω to V_{CC} – 2V. For V_{CC} = 2.5V, the V_{CC} – 2V is very close to ground level. The R3 in Figure 4B can be eliminated and the termination is shown in *Figure 4C.*

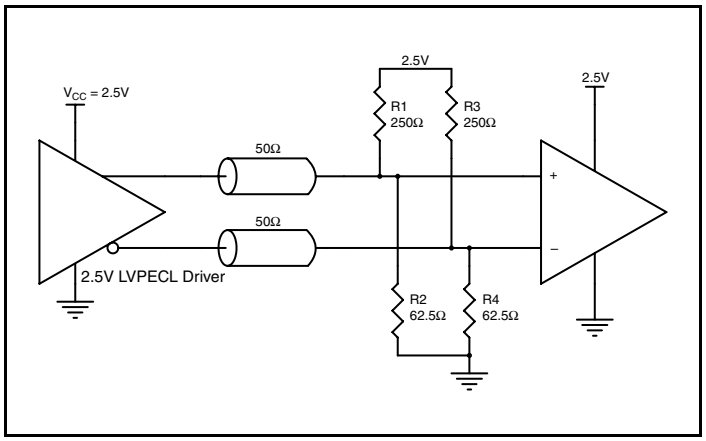


Figure 4A. 2.5V LVPECL Driver Termination Example

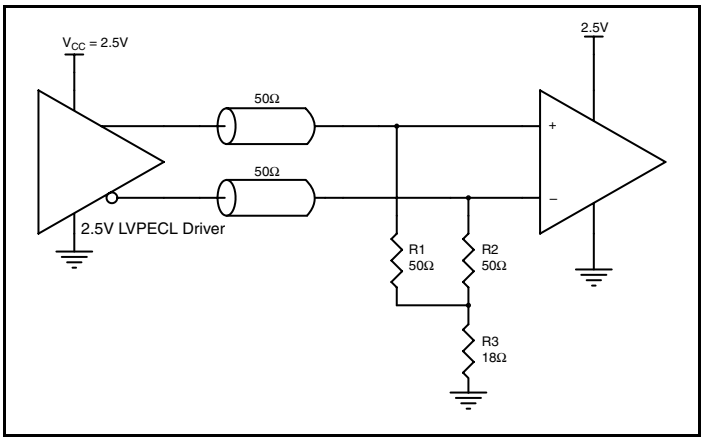


Figure 4B. 2.5V LVPECL Driver Termination Example

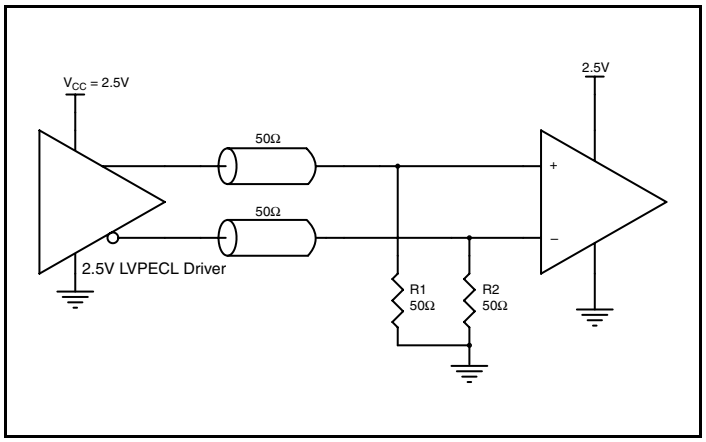


Figure 4C. 2.5V LVPECL Driver Termination Example

Power Considerations

This section provides information on power dissipation and junction temperature for the ICS853S013I.
Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the CS853S013I is the sum of the core power plus the power dissipated in the load(s).
The following is the power dissipation for V_{CC} = 3.8V, which gives worst case results.

NOTE: Please refer to Section 3 for details on calculating power dissipated in the load.

- Power $(core)_{MAX} = V_{CC\_MAX} * I_{EE\_MAX}$ = 3.8V * 50mA = **190mW**
- Power $(outputs)_{MAX}$ = **30.07mW/Loaded Output pair**
  If all outputs are loaded, the total power is 6 *30.07mW = **180.43mW**

Total Power$_{\_MAX}$ (3.8V, with all outputs switching) =190mW + 180.43mW = **370.43mW**

2. Junction Temperature.

Junction temperature, Tj, is the temperature at the junction of the bond wire and bond pad directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature, Tj, to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for Tj is as follows: $Tj = \theta_{JA} * Pd\_total + T_A$

Tj = Junction Temperature

θ_{JA} = Junction-to-Ambient Thermal Resistance

Pd_total = Total Device Power Dissipation (example calculation is in section 1 above)

T_A = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance θ_{JA} must be used. Assuming no air flow and a multi-layer board, the appropriate value is 71.1°C/W per Table 6 below.

Therefore, Tj for an ambient temperature of 85°C with all outputs switching is:

85°C + 0.370W * 71.1°C/W = 111.3°C. This is well below the limit of 125°C.

This calculation is only an example. Tj will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

Table 6. Thermal Resistance θ_{JA} for 20 Lead SOIC, Forced Convection

θ_{JA} **by Velocity**			
Meters per Second	**0**	**200**	**500**
Multi-Layer PCB, JEDEC Standard Test Boards	71.1°C/W	65.2°C/W	62°C/W

3. Calculations and Equations.

The purpose of this section is to derive the power dissipated into the load.

LVPECL output driver circuit and termination are shown in *Figure 5.*

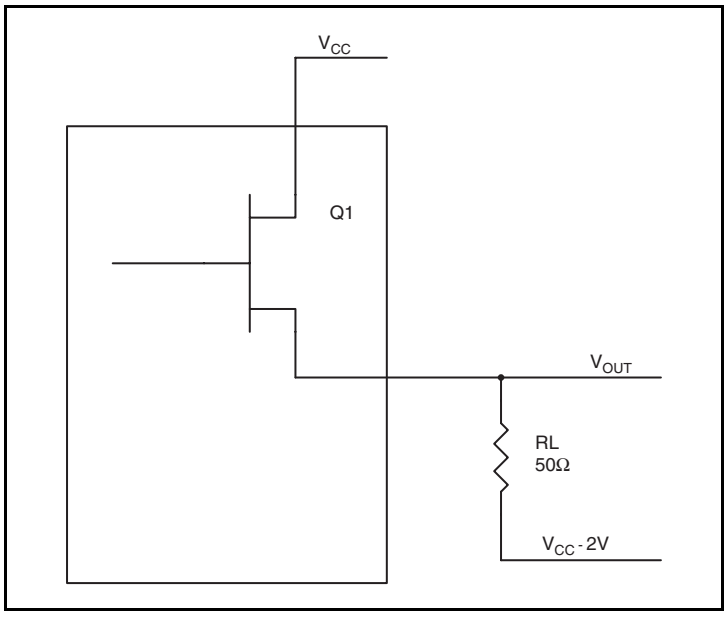


Figure 5. LVPECL Driver Circuit and Termination

To calculate worst case power dissipation into the load, use the following equations which assume a 50Ω load, and a termination voltage of V_{CC} – 2V.

- For logic high, $V_{OUT} = V_{OH\_MAX} = \mathbf{V_{CC\_MAX} – 0.815V}$
  $(V_{CC\_MAX} – V_{OH\_MAX}) = \mathbf{0.815V}$
- For logic low, $V_{OUT} = V_{OL\_MAX} = \mathbf{V_{CC\_MAX} – 1.68V}$
  $(V_{CC\_MAX} – V_{OL\_MAX}) = \mathbf{1.68V}$

Pd_H is power dissipation when the output drives high.

Pd_L is the power dissipation when the output drives low.

$Pd\_H = [(V_{OH\_MAX} – (V_{CC\_MAX} – 2V))/R_L] * (V_{CC\_MAX} – V_{OH\_MAX}) = [(2V – (V_{CC\_MAX} – V_{OH\_MAX}))/R_L] * (V_{CC\_MAX} – V_{OH\_MAX}) =$
$[(2V – 0.815V)/50\Omega] * 0.815V =$ **19.32mW**

$Pd\_L = [(V_{OL\_MAX} – (V_{CC\_MAX} – 2V))/R_L] * (V_{CC\_MAX} – V_{OL\_MAX}) = [(2V – (V_{CC\_MAX} – V_{OL\_MAX}))/R_{L]} * (V_{CC\_MAX} – V_{OL\_MAX}) =$
$[(2V – 1.68V)/50\Omega] * 1.68V =$ **10.75mW**

Total Power Dissipation per output pair = Pd_H + Pd_L = **30.07mW**

Reliability Information

Table 7. θ_{JA} vs. Air Flow Table for a 20 Lead SOIC

θ_{JA} by Velocity			
Meters per Second	**0**	**200**	**500**
Multi-Layer PCB, JEDEC Standard Test Boards	71.1°C/W	65.2°C/W	62°C/W

Transistor Count

The transistor count for ICS853S013I is: 270

This device is pin and function compatible and a suggested replacement for the ICS853013.

Package Outline and Package Dimensions

Package Outline - M Suffix for 20 Lead SOIC

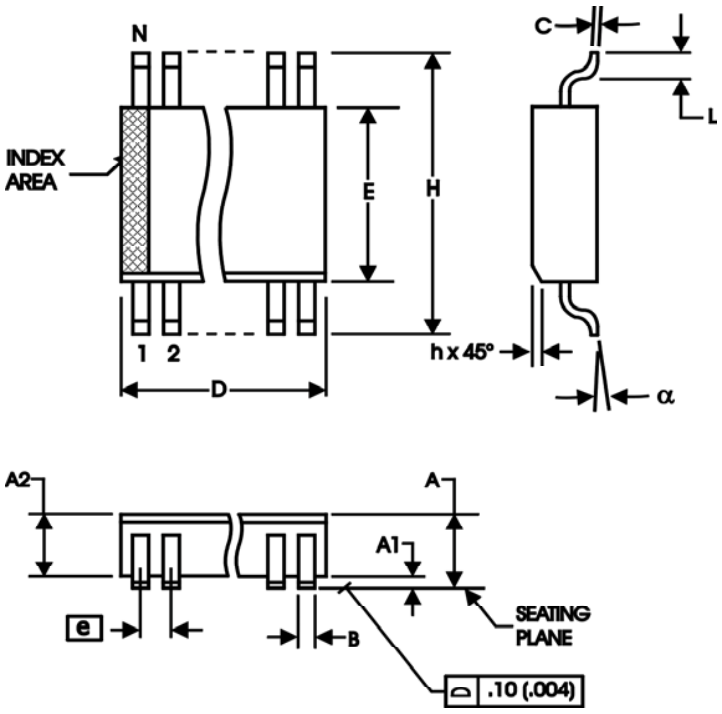


Table 8. Package Dimensions for 20 Lead SOIC

300 Millimeters All Dimensions in Millimeters		
Symbol	**Minimum**	**Maximum**
N	20	
A		2.65
A1	0.10	
A2	2.05	2.55
B	0.33	0.51
C	0.18	0.32
D	12.60	13.00
E	7.40	7.60
e	1.27 Basic	
H	10.00	10.65
h	0.25	0.75
L	0.40	1.27
α	0°	7°

Reference Document: JEDEC Publication 95, MS-013, MS-119

Ordering Information

Table 9. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
853S013AMILF	ICS853S013AMILF	“Lead-Free” 20 Lead SOIC	Tube	-40°C to 85°C
853S013AMILFT	ICS853S013AMILF	“Lead-Free” 20 Lead SOIC	1000 Tape & Reel	-40°C to 85°C

NOTE: Parts that are ordered with an “LF” suffix to the part number are the Pb-Free configuration and are RoHS compliant.

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